

WHAT IS CLAIMED IS:

1. An electron-emitting apparatus comprising:

A) a first electrode and a second electrode  
disposed on a surface of a substrate;

5 B) first voltage application means for applying to  
said second electrode a potential higher than a  
potential applied to said first electrode;

C) an electron-emitting member disposed on said  
first electrode;

10 D) a third electrode disposed so as to face said  
substrate, electrons emitted from said electron-  
emitting member reaching said third electrode; and

E) second voltage application means for applying  
to said third electrode a potential higher than each of  
15 the potentials applied to said first and second  
electrodes,

wherein a surface of said electron-emitting member  
is placed between a plane containing a surface of said  
second electrode and substantially parallel to the  
20 surface of said substrate and a plane containing a  
surface of said third electrode and substantially  
parallel to the surface of said substrate, and

wherein when the distance between said second  
electrode and said first electrode is  $d$ ; the potential  
25 difference applied between said second electrode and  
said first electrode by said first voltage application  
means is  $V_1$ ; the distance between said third electrode

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and said substrate is H; and the potential difference between the potential applied to said third electrode by said second voltage application means and the potential applied to said first electrode by said first  
5 voltage application means is V2, then an electric field  $E1 = V1/d$  is within the range from 1 to 50 times an electric field  $E2 = V2/H$ .

2. An apparatus according to claim 1, wherein the  
10 thickness of said first electrode is larger than the thickness of said second electrode.

3. An apparatus according to claim 1, wherein  
15 said electron-emitting member extends from a position on said first electrode to a position on said substrate between said first electrode and said second electrode.

4. An apparatus according to claim 1, wherein  
20 said substrate has a difference in level between said second electrode and said first electrode, and said third electrode is closer to said first electrode than to said second electrode.

5. An apparatus according to claim 1, wherein  
25 said electron-emitting member is made of a material containing carbon as a main ingredient.

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6. An apparatus according to claim 5, wherein said material containing carbon as a main ingredient comprises fibrous carbon.

5           7. An apparatus according to claim 6, wherein said fibrous carbon comprises a graphite nanofiber, a carbon nanotube, amorphous carbon, or a mixture of at least two of these materials.

10           8. An apparatus according to claim 7, wherein said fibrous carbon is grown by means of catalytic particles.

15           9. An apparatus according to claim 8, wherein catalytic particles are made of Pd, Ni, Fe, Co or an alloy of at least two of these metals.

20           10. An apparatus according to any one of claims 1 to 9, wherein a plurality of said first electrodes and a plurality of said second electrodes are disposed on the surface of said substrate.

25           11. An apparatus according to claim 10, wherein said plurality of first electrodes and said plurality of second electrodes are electrically connected to wiring in matrix form.

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12. An apparatus according to claim 10, wherein a phosphor capable of emitting light when irradiated with electrons emitted from said electron-emitting member is provided on said third electrode.

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13. An image display apparatus using an electron-emitting apparatus according to claim 12.

14. An electron-emitting device comprising:

10 A) a fiber containing carbon as a main ingredient;  
and

B) an electrode for controlling emission of electrodes from said fiber containing carbon as a main ingredient,

15 wherein said fiber containing carbon as a main ingredient has a plurality of graphenes layered so as not to be parallel to the axis direction of said fiber.

20 15. An electron-emitting device according to claim 14, wherein the plurality of graphenes are substantially parallel to each other.

25 16. An electron-emitting device according to claim 14, further comprising a cathode, wherein said fiber containing carbon as a main ingredient is provided on said cathode and is electrically connected to said cathode.

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17. An electron-emitting device according to claim 16, wherein said cathode and said electrode for controlling emission of electrons are disposed on one substrate, a gap being formed between said cathode and said electrode for controlling emission of electrons.

18. An electron-emitting device according to claim 14, wherein said electron-emitting device comprises a plurality of said fibers containing carbon as a main ingredient.

19. A light-emitting apparatus comprising an electron-emitting device according to any one of claims 14 to 18, and a light-emitting member.

20. An image display apparatus comprising a plurality of electron-emitting devices and a light emitting member capable of emitting light when irradiated with electrons emitted from some of said plurality of electron-emitting devices, wherein each of said plurality of electron-emitting devices is constituted by the electron-emitting device according to any one of claims 14 to 18.

21. An electron-emitting apparatus comprising:  
A) a first electrode and a second electrode disposed on a surface of a substrate;

B) first voltage application means for applying to said second electrode a potential higher than a potential applied to said first electrode;

C) a plurality of fibers disposed on said first electrode, said fibers containing carbon as a main constituent;

D) a third electrode disposed so as to face said substrate, electrons emitted from said fibers reaching said third electrode; and

E) second voltage application means for applying to said third electrode a potential higher than each of the potentials applied to said first and second electrodes,

wherein a surface region of said fibers is placed between a plane containing a surface of said second electrode and substantially parallel to the surface of said substrate and a plane containing a surface of said third electrode and substantially parallel to the surface of said substrate.

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22. An electron-emitting apparatus according to claim 21, wherein when the distance between said second electrode and said first electrode is  $d$ ; the potential difference applied between said second electrode and said first electrode by said first voltage application means is  $V_1$ ; the distance between said third electrode and said substrate is  $H$ ; and the potential difference

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between the potential applied to said third electrode  
by said second voltage application means and the  
potential applied to said first electrode is  $V_2$ , then  
an electric field  $E_1 = V_1/d$  is within the range from 1  
5 to 50 times an electric field  $E_2 = V_2/H$ .

23. An apparatus according to claim 21, wherein  
each of said fibers having carbon as a main ingredient  
comprises a carbon nanotube.  
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24. An apparatus according to claim 21, wherein  
each of said fibers containing carbon as a main  
ingredient comprises a plurality of graphenes stacked  
so as to be nonparallel to the axis direction of said  
15 fiber.

25. An apparatus according to claim 21, wherein a  
material more effective in accelerating deposition of  
carbon than the material of said first electrode is  
20 provided between said fibers having carbon as a main  
ingredient and said cathode.

26. An apparatus according to claim 25, wherein  
said material effective in accelerating deposition of  
25 carbon comprises Pd, Ni, Fe, Co or an alloy formed of  
at least two of said metals.

27. An apparatus according to claim 25, wherein said material effective in accelerating deposition of carbon is provided in the form of a plurality of particles on said first electrode.

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28. An apparatus according to claim 27, wherein said plurality of particles are provided on said first electrode at a density of  $10^{10}$  particles/cm<sup>2</sup> or higher.

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29. An apparatus according to claim 21, wherein the thickness of said first electrode is larger than the thickness of said second electrode.

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30. An apparatus according to any one of claims 21 to 29, wherein a plurality of said first electrodes and a plurality of said second electrodes are disposed on the surface of said substrate.

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31. An apparatus according to claim 30, wherein said plurality of first electrodes and said plurality of second electrodes are electrically connected to wiring in matrix form.

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32. An apparatus according to claim 30, wherein a phosphor capable of emitting light when irradiated with electrons emitted from said fibers is provided on said third electrode.

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33. An image display apparatus using an electron-emitting apparatus according to claim 32.

34. An electron-emitting device comprising:

5       A) a first electrode and a second electrode disposed on a surface of a substrate, a gap being formed between said first and second electrodes; and

      B) a fiber provided on said first electrode, said fiber containing carbon as a main ingredient,

10       wherein said second electrode comprises an electrode for controlling emission of electrodes from said fiber containing carbon as a main ingredient, and

      wherein said fiber containing carbon as a main ingredient comprises graphene.

15       35. An electron-emitting device according to claim 34, wherein the distance between an extreme end of said fiber and the surface of said substrate is larger than the distance between the surface of said  
20       second electrode and the surface of said substrate.

      36. An electron-emitting device according to claim 34, wherein said graphene comprises cylindrical graphene.

25       37. An electron-emitting device according to claim 34, wherein said electron-emitting device

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comprises a plurality of fibers containing carbon as a main ingredient.

38. A light-emitting apparatus comprising an  
5 electron-emitting device according to any one of claims  
34 to 37, and a light-emitting member.

39. An image display apparatus comprising a  
plurality of electron-emitting devices and a light  
10 emitting member capable of emitting light when  
irradiated with electrons emitted from some of said  
plurality of electron-emitting devices, wherein each of  
said plurality of electron-emitting devices is  
constituted by an electron-emitting device according to  
15 any one of claims 34 to 37.

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